CLAIMS

1. A method for conducting electroplating in the presence of CO_2 and a metal salt-containing aqueous solution, the CO_2 being liquid, subcritical or supercritical, the method further comprising a step of adding a nonionic compound having a CO_2-affinitive moiety to a system wherein the aqueous solution and CO_2 coexist, the CO_2-affinitive moiety being at least one member selected from the group consisting of:

(1) homopolymers, bicopolymers and tricopolymers of polyoxypropylene, polyoxybutylene and/or polyoxyethylene;

(2) fluorine-containing alkyl groups in which some or all of the hydrogen atoms are substituted by fluorine;

(3) fluorine-containing polyether groups in which some or all of the hydrogen atoms are substituted by fluorine; and

(4) dialkylsiloxy groups.

2. The method according to Claim 1, wherein the nonionic compound is an ether-based or ester-based compound.

3. The method according to Claim 1, wherein the nonionic compound is an alcohol-based compound.

4. The method according to Claim 1, wherein the nonionic compound is a fluorinated hydrocarbon.

5. The method according to Claim 1, wherein the nonionic compound is a polyalkylsiloxane.

6. The method according to Claim 1, wherein the nonionic compound is a fluorine-containing polymer.

7. A plating bath comprising a metal salt-containing aqueous solution, CO_2, and a nonionic compound having a CO_2-affinitive moiety, the CO_2 being liquid, subcritical or

supercritical, the CO_2-affinitive moiety being at least one member selected from the group consisting of:

(1) homopolymers, bicopolymers and tricopolymers of polyoxypropylene, polyoxybutylene and/or polyoxyethylene;

(2) fluorine-containing alkyl groups in which some or all of the hydrogen atoms are substituted by fluorine;

(3) fluorine-containing polyether groups in which some or all of the hydrogen atoms are substituted by fluorine; and

(4) dialkylsiloxy groups.

8. An additive for use in electroplating conducted in the presence of liquid, subcritical or supercritical CO_2, the additive comprising a nonionic compound having a CO_2-affinitive moiety,

the CO_2-affinitive moiety being at least one member selected from the group consisting of:

(1) homopolymers, bicopolymers and tricopolymers of polyoxypropylene, polyoxybutylene and/or polyoxyethylene;

(2) fluorine-containing alkyl groups in which some or all of the hydrogen atoms are substituted by fluorine;

(3) fluorine-containing polyether groups in which some or all of the hydrogen atoms are substituted by fluorine; and

(4) dialkylsiloxy groups.

9. A method for preprocessing conducted before plating comprising the step of degreasing and washing a plating substrate prior to plating using a nonionic compound having a CO_2-affinitive moiety,

the CO_2-affinitive moiety being at least one member selected from the group consisting of:

(1) homopolymers, bicopolymers and tricopolymers of polyoxypropylene, polyoxybutylene and/or polyoxyethylene;

(2) fluorine-containing alkyl groups in which some or all of the hydrogen atoms are substituted by fluorine;

(3) fluorine-containing polyether groups in which some

or all of the hydrogen atoms are substituted by fluorine; and

(4) dialkylsiloxy groups.

10. A method for postprocessing conducted after plating comprising the step of washing a plated film after plating using a nonionic compound having a CO_2-affinitive moiety, the CO_2-affinitive moiety being at least one member selected from the group consisting of:

(1) homopolymers, bicopolymers and tricopolymers of polyoxypropylene, polyoxybutylene and/or polyoxyethylene;

(2) fluorine-containing alkyl groups in which some or all of the hydrogen atoms are substituted by fluorine;

(3) fluorine-containing polyether groups in which some or all of the hydrogen atoms are substituted by fluorine; and

(4) dialkylsiloxy groups.

11. A plated film having

(1) per cm^2, not more than one pinhole having a diameter of at least 1 μm;

(2) a film thickness of not more than 1 μm; and

(3) a plated film surface roughness of not greater than 10 nm.

12. The method according to Claim 1, wherein the nonionic compound used is (CO_2-affinitive moiety)-X- or X-(CO_2-affinitive moiety)-X- of 1) or 2) below respectively:

1) $F-(CF_2)_q-(OCF_3F_6)_m-(OC_2F_4)_n-(OCF_2)_o-(CH_2)_p-$ X-, or

2) $-X-(CH_2)_p-(CF_2O)_o-(C_2F_4O)_n-(C_3F_6O)_m-(CF_2)_q-(OC_3F_6)_m-(OC_2F_4)_n-(OCF_2)_o-(CH_2)_p-X-$,

wherein m, n, o, p, and q are integers not smaller than 0, m and n are integers from 0 to 15 but not both 0, $n + m \leq 20$, o = 0 to 20, p = 0 to 2, and q = 1 to 10; the sequence of the repeating units not being fixed; $-(OC_3F_6)_m-$ represents $-(OCF_2CF_2CF_2)_m-$ or $-(OCF(CF_3)CF_2)_m-$, and $-(OC_2F_4)_n-$ represents $-(OCF_2CF_2)_n-$ or $-(OCF(CF_3))_n-$, and

each X may be the same or different, and represents a single bond, or O, S, NH, NR (R^a: alkyl group), C=O, C(O)O, OC(O), C(O)S, SC(O), C(O)NH, C(O)NR^a (R^a: alkyl group), NH(O)C, NR(O)C, CH_2, CHR^a, CR^a_2 (R^a: alkyl group), SO_2NH, or $NHSO_2$.

13. The method according to Claim 1, wherein the nonionic compound is one of 1) to 3):

1) $F-(CF_2)_q-(OC_3F_6)_m-(OC_2F_4)_n-(OCF_2)_o-(CH_2)_pX-R_h$,

2) $F-(CF_2)_q-(OC_3F_6)_m-(OC_2F_4)_n-(OCF_2)_o-(CH_2)_pX-R_h-X-(CH_2)_p-(CF_2O)_o-(C_2F_4O)_n-(C_3F_6O)_m-(CF_2)_q-F$, and

3) $R_h-X(CH_2)_p-(CF_2O)_o-(C_2F_4O)_n-(C_3F_6O)_m-(CF_2)_q-(OC_3F_6)_m-(OC_2F_4)_n-(OCF_2)_o-(CH_2)_pX-R_h$,

wherein m, n, o, p, and q are integers not smaller than 0, m and n are integers from 0 to 15 but not both 0, $n + m \leq 20$, o = 0 to 20, p = 0 to 2, and q = 1 to 10; the sequence of the repeating units not being fixed; $-(OC_3F_6)_m-$ represents $-(OCF_2CF_2CF_2)_m-$ or $-(OCF(CF_3)CF_2)_m-$, and $-(OC_2F_4)_n-$ represents $-(OCF_2CF_2)_n-$ or $-(OCF(CF_3))_n-$, and

each X may be the same or different, and represents a single bond, or O, S, NH, NR (R^a: alkyl group), C=O, C(O)O, OC(O), C(O)S, SC(O), C(O)NH, C(O)NR^a (R^a: alkyl group), NH(O)C, NR(O)C, CH_2, CHR^a, CR^a_2 (R^a: alkyl group), SO_2NH, or $NHSO_2$, and each R_h is a hydrophilic moiety and a straight or branched chain hydrocarbon group that may contain hetero atoms.

14. The method according to Claim 13, wherein R_h is a polyoxyalkylene group.

15. The method according to Claim 13, wherein the nonionic compound comprises a CO_2-affinitive moiety whose number of carbon atoms is the same as or greater than that of the R_h group.

16. The method according to Claim 1, wherein the nonionic compound comprises (CO_2-affinitive moiety)-X- or X-(CO_2-

affinitive moiety)-X- of 1) or 2) below respectively:

1) $Y-(CF_2)_{m1}-(CH_2)_{n1}-X$, or

2) $X-(CH_2)_{n1}-(CF_2)_{m1}-(CH_2)_{n1}-X$,

wherein Y is F or H, each X may be the same or different and represents one member selected from the group consisting of COO, O, S, CONH, NHCO, SO_2NH, and $NHSO_2$, m1 is an integer from 3 to 20, and each n1 may be the same or different and represents an integer from 0 to 2.

17. The method according to Claim 16, wherein the nonionic compound is one of 1) to 3) below respectively:

1) $Y-(CF_2)_{m1}-(CH_2)_{n1}-X-R_h$,

2) $Y-(CF_2)_{m1}-(CH_2)_{n1}-X-R_h-X-(CH_2)_{n1}-(CF_2)_{m1}-Y$, or

3) $R_h-X-(CH_2)_{n1}-(CF_2)_{m1}-(CH_2)_{n1}-X-R_h$,

wherein Y is F or H, each X may be the same or different and represents one member selected from the group consisting of COO, O, S, CONH, NHCO, SO_2NH, and $NHSO_2$, each m1 may be the same or different and represents an integer from 3 to 20, each n1 may be the same or different and represents an integer from 0 to 2, and each R_h is a hydrophilic moiety and straight or branched chain hydrocarbon group that may contain hetero atoms.

18. The method according to Claim 17, wherein R_h is a polyoxyalkylene group.

19. The method according to Claim 17, wherein the nonionic compound comprises a CO_2-affinitive moiety whose number of carbon atoms is the same as or greater than that of each R_h group.